SOME RELATIONSHIPS BETWEEN SOIL CONDITIONS AND DISTRIBUTION OF DIFFERENT FOREST VEGETATION

J. LÅG

Agricultural College of Norway, Vollebekk, Norway

In the period 1954—1965, elementary investigations of a larger part of the forest area of Norway were carried out in connection with the ordinary registrations of Landskogstakseringen (The National Forest Survey). More than 100.000 sample plots, systematically distributed over more than 5 mill. hectares of productive forest, were investigated.

The results of the investigations have been presented in a series of district descriptions. Soil depth and main types of soil profiles throughout the area have been compaired (LÅG 1967, 1970). In these publications references are made to previous works. Special questions have been dealt with in separate publications, e.g. quantitative expressions of the influence of different soil-forming factors, and measuring of the productivity of the various main soil types (LÅG 1968).

Relationships between soil conditions and vegetation have been treated in the separate district publications. Special comparisons have been made, but a survey of the whole material has not been made previously.

In the field survey, the forest was grouped according to the tree species into the following classes:

1. Forest of Norway spruce
2. Forest of Scots pine
3. Mixed coniferous forest
4. Other types of mixed forest of coniferous and broad-leaved trees
5. Broad-leaved forest

For some counties, the broad-leaved forest has been subdivided into oak forest, birch forest, aspen forest, and other types of broad-leaved forest. In this comparison, however, these groups have been gathered under the denomination broad-leaved forest.

The registration includes only productive forest, i.e. areas with a normal annual increment exceeding 1.2 m^3 per hectare. Thus the investigation do not include the zone of birch forest extending towards the high mountains.

The ground cover vegetation has been divided into the following types:

1. Forest without ground cover vegetation (forest litter only)
2. Forest ground rich in grasses and herbs

Fig. 1. Cross-hatching indicates areas where the forest soils have been investigated.

3. Forest ground rich in mosses and with some herbs
4. Forest ground rich in *Vaccinium myrtillus* with *Dryopteris*
5. Forest ground rich in *Vaccinium myrtillus* without *Dryopteris*
6. Forest ground rich in *Vaccinium vitis-idaea*
7. Forest ground rich in *Calluna vulgaris*
8. Forest ground rich in lichens
9. Water-logged forest ground
10. Forest ground rich in *Deschampsia flexuosa*

The first and the last vegetational types cover relatively small areas, and were not separated from the other types in some of the areas surveyed in the beginning.

The map (Fig. 1) shows the situation of areas where the forest ground has been investigated.

Some groupings showing the connections between soil conditions and vegetation are presented in Figs. 2—5. In calculating the distribution of types of ground cover vegetation and tree species the percentages were rounded off to integers.

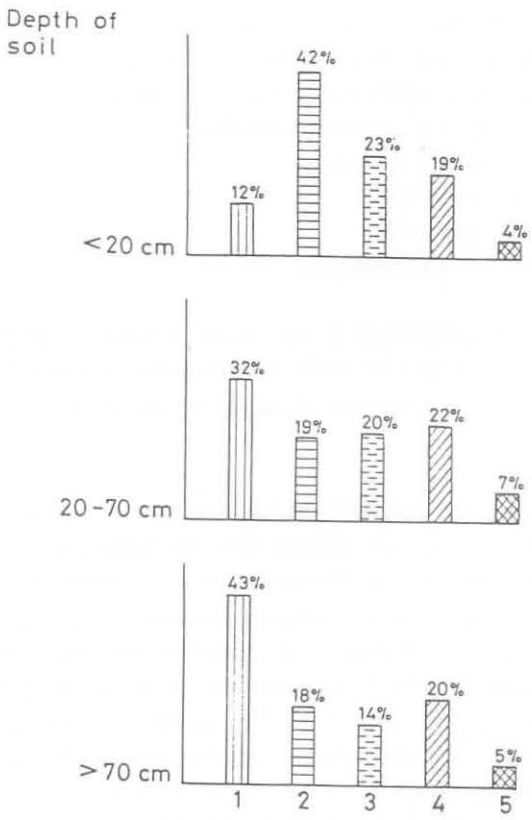
The present paper deals only with relations between soil depth and main profile types on the one hand and tree species and ground cover vegetation on the other hand. Previous comparisons for the whole country show the distribution of the soil depth to be 11.0 % in the class <20 cm, 34.8 % in 20—70 cm, and 54.2 % in >70 cm (LÅG 1967). A corresponding distribution of the area in the main groups of soil profiles gave 80.1 % of podzol, 12.5 % of brown earth, 2.3 % of transitions between brown earth and podzol, and 5.1 % of swamp soil (LÅG 1970).

Details of the classification system of tree species, ground cover vegetation, soil depth, and profile type, etc. are shown in the instructions on which the field work has been based (see e.g. Instruks . . . 1962).

The total soil depth is in general a primary quality of the habitat of the plants. It is therefore relatively simple in this connection to interpret causal relationships in the distribution of the vegetation. However, there will to a certain extent be a mutual dependence between the soil profile development and the vegetation which makes it more difficult to explain cause and effect. Nevertheless, some knowledge of the relationship of these factors may be of great interest.

As will be seen from Fig. 2, the soil depth has influence on the distribution of tree species. The pine forest is overrepresented on the more shallow soils and the spruce forest is over-represented on the deep soils. Relatively there is slightly more of mixed coniferous forest on shallow than on deep soil. For the other two groups of tree species no close correlation was found.

With such a rough comparison for the whole country a lot of details do not emerge. From more detailed examinations of the material we know that, e.g. pine forest dominates on special types of coarse quaternary deposits. These areas are relatively small, compared with those of the whole country. Such well known exceptions can almost be said to confirm the principal rules.



1 Forest of Norway spruce
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5 Broad-leaved forest

Fig. 2. Relationships between soil depth and tree species

The ground cover vegetation is also dependent on the soil depth (Fig. 3). The three vegetational types, forest ground rich in grasses and herbs, forest ground rich in mosses and with some herbs, and forest ground rich in *Vaccinium myrtillus* with *Dryopteris*, are relatively far more common on deep than on shallow soils. Forest ground rich in *Calluna vulgaris* is comparatively more frequent on shallow than on deep soils. This applies to some extent to forest ground rich in lichens as well.

Water-logged forest ground is in some measure in a special situation, being usually associated with an accumulation of humus. It is therefore easy to understand why this type of vegetation is particularly frequent on deep soil. From a botanical point of view, this group is very heterogeneous.

Forest ground rich in *Vaccinium vitis-idaea* and forest ground rich in lichens are more frequent in the depth class <20 cm than in the class 20—70 cm. The situation for these two types of ground cover vegetation seem to be alike that mentioned for

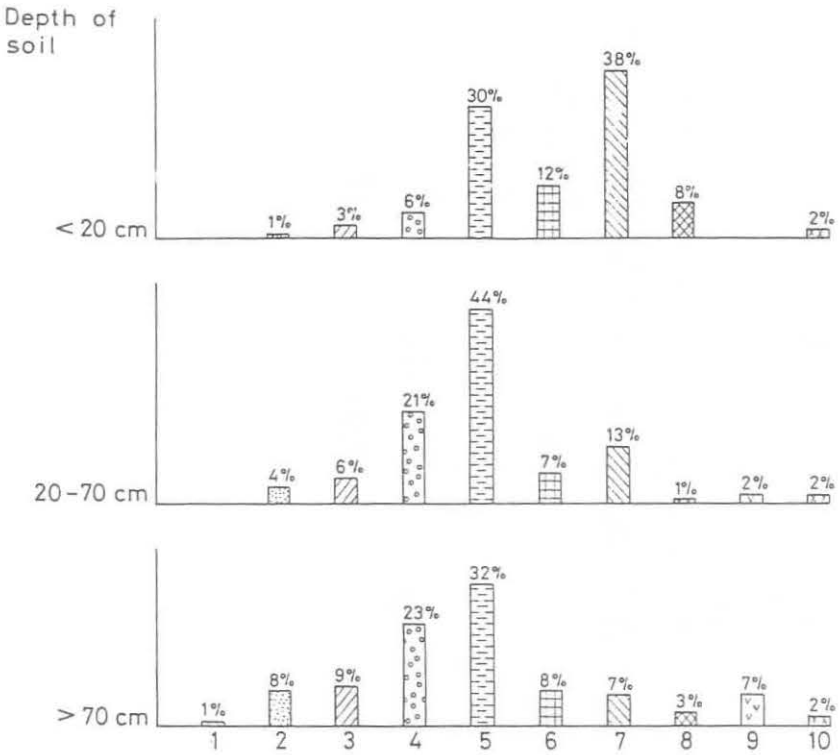

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Fig. 3. Relationships between soil depth and ground cover vegetation

the pine forest. Besides occurring on very shallow soils, *Vaccinium vitis-idaea* and lichens appear quite often on deep coarse-grained deposits.

Connections between soil-development and distribution of vegetation are shown in Figs. 4–5.

Forests of Scots pine and mixed coniferous forest are particularly associated with podzol soil. Forest of Norway spruce and broad-leaved forest are relatively more frequent on brown earth. The investigations do not include the birch forest area above the timbre line of conifers. In Norway most of these areas have podzol soil.

The two types of ground cover vegetation, forest ground rich in grasses and herbs, and forest ground rich in mosses and with some herbs, are over-represented on brown earth (Fig. 5).

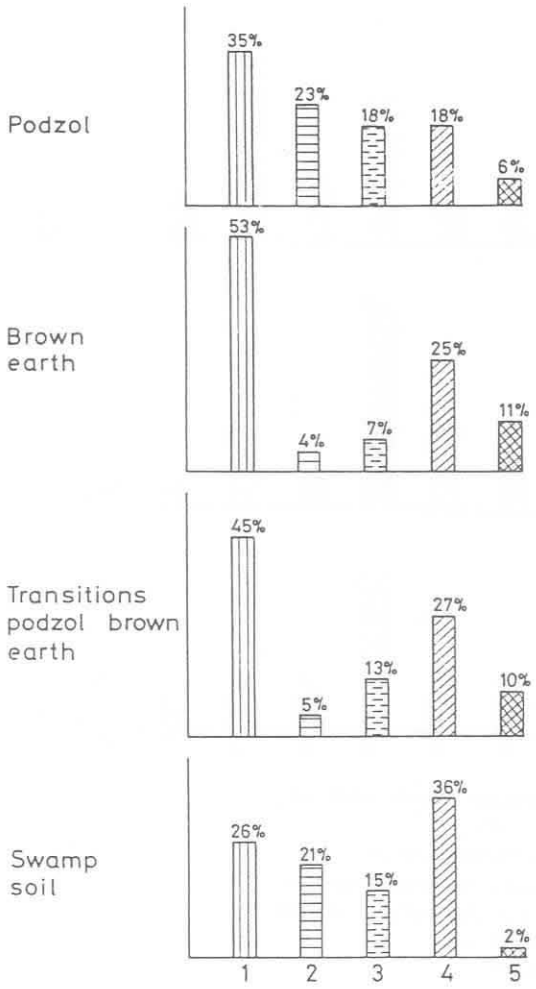

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Fig. 4. Relationships between main soil type and tree species

Forest ground rich in lichens, forest ground rich in *Calluna vulgaris*, forest ground rich in *Vaccinium vitis-idaea*, and forest ground rich in *Vaccinium myrtillus* without *Dryopteris*, are found mainly on podzol soil. As one could imagine, there is quite high frequency of the vegetation type water-logged forest ground on swamp soil. By comparison, stronger relationships are found between soil conditions and ground cover vegetation than between soil conditions and tree species.

Among foresters a great deal of discussion has been going on about the influence of changes of tree species of a stand on the soil conditions. These comparisons show the ground cover vegetation to be of greater importance than the tree stand.

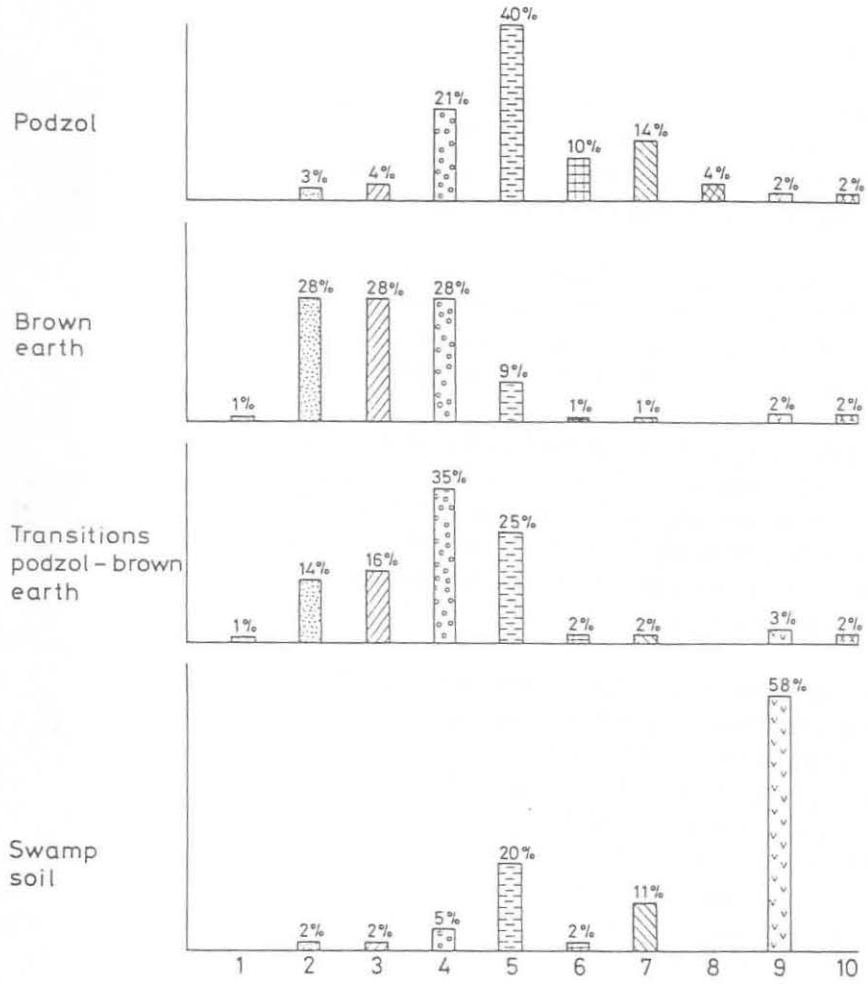

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Fig. 5. Relationships between main soil type and ground cover vegetation

When the material for the entire country was treated as a whole, few small areas with untypical relationships between soil conditions and forest vegetation also appeared. For instance, registrations of previous cultivated areas recently overgrown may give a combination of pine forest with *Calluna vulgaris* on brown earth.

Some errors due to mistakes committed during field work may occure in such a large numerical material.

Summary and Conclusions

An account is given of the relationships between the soil depth and the main type of soil on the one hand and the distribution of tree species and ground cover vegetation on the other hand in a material including more than 100000 sample plots, systematically distributed over more than 5 million hectares of productive forest in Norway.

The forest of Scots pine and the mixed coniferous forest are relatively more common on shallow soils, while the forest of Norway spruce dominates on deep soils. The pine forest for example represents 42 % and spruce forest 12 % of the area with soil depth under 20 cm, as against 18 % and 43 % for soil deeper than 70 cm.

The three types of ground cover vegetation, 1) forest ground rich in grasses and herbs, 2) forest ground rich in mosses and with some herbs, 3) and forest ground rich in *Vaccinium myrtillus* with *Dryopteris*, are especially common on deep soils. Together, they cover 10 % of the area with soil depth under 20 cm and 40 % of the area with soil depth over 70 cm. Forest ground rich in *Calluna vulgaris* on the other hand represents 38 % of the area in the former depth class, and only 7 % in the latter.

Forest of Scots pine and mixed coniferous forest are closely associated with podzol. Forest of Norway spruce and broad-leaved forest have a higher frequency on brown earth. Forest of Scots pine covers 23 % of the podzol area, but only 4 % of the brown earth area. The corresponding figures for forest of Norway spruce are 35 % and 53 %, and for broad-leaved forest 6 % and 11 %, respectively.

The types of ground cover vegetation, forest ground rich in *Vaccinium myrtillus* without *Dryopteris*, forest ground rich in *Vaccinium vitis-idaea*, forest ground rich in *Calluna vulgaris*, and forest ground rich in lichens, are usually connected with podzol. soil. These four types together cover 68 % of the podzol area, but only 11 % of the brown earth area.

Forest ground rich in grasses and herbs, and forest ground rich in mosses and with some herbs, are closely associated with brown earth. Together, these two types cover only 7 % of the area with podzol soil, but 56 % of that with brown earth.

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